

Islamic Manuscripts in the Schoenberg Collection at Pennsylvania University

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by: The Editorial Team

The Lawrence J. Schoenberg Collection at the University of Pennsylvania is a private library focusing on late medieval and early

modern manuscripts. The collection contains a valuable set of original manuscripts, a great part of which can be viewed online through a dedicated website, after having been digitized by the Schoenberg Center for Electronic Text and Image. The Islamic manuscripts form a significant part of the collection, including Al-Karaji's *Inbat al-miyah al-khafiya*, Al-Khazini's *Kitab mizan al-hikma*, and various manuscripts of medicine, logic, mathematics, literature and several copies of the Quran. The following article presents the Schoenberg Collection, with a focus on some selected Islamic manuscripts of science and medicine.

Table of contents

- 1. Introduction
- 2. The Initiative and the Collection
- 3. The Catalogue
- 4. Exhibition at the Getty Center in Los Angeles
- 5. Selected Islamic manuscripts of science and medicine in Schoeneberg's collection
 - 5.1. Manuscript LJS 049
 - 5.2. Manuscript LJS 051
 - 5.3. Manuscript LJS 355
 - 5.4. Manuscript LJS 386
 - 5.5. Manuscript LJS 399
- 6. Appendix
- 7. Resources and further reading

1. Introduction

The Lawrence J. Schoenberg Collection is a private library focusing on late medieval and early modern manuscripts. Mr. Schoenberg is a Penn alumnus and past chair of the Library's Board of Overseers. It has long been his desire that private collectors do more to facilitate access by scholars to their collections. The advent of the World Wide Web has now made it possible for private and institutional collections to be seen as scanned images and as encoded text. And so, the University of Pennsylvania Libraries have entered into a unique collaboration with L. J. Schoenberg that allows researchers to view virtual facsimiles of manuscripts from his collection. While it will take several years to finish the project, scholars will be able to see and use texts as they become progressively available online.

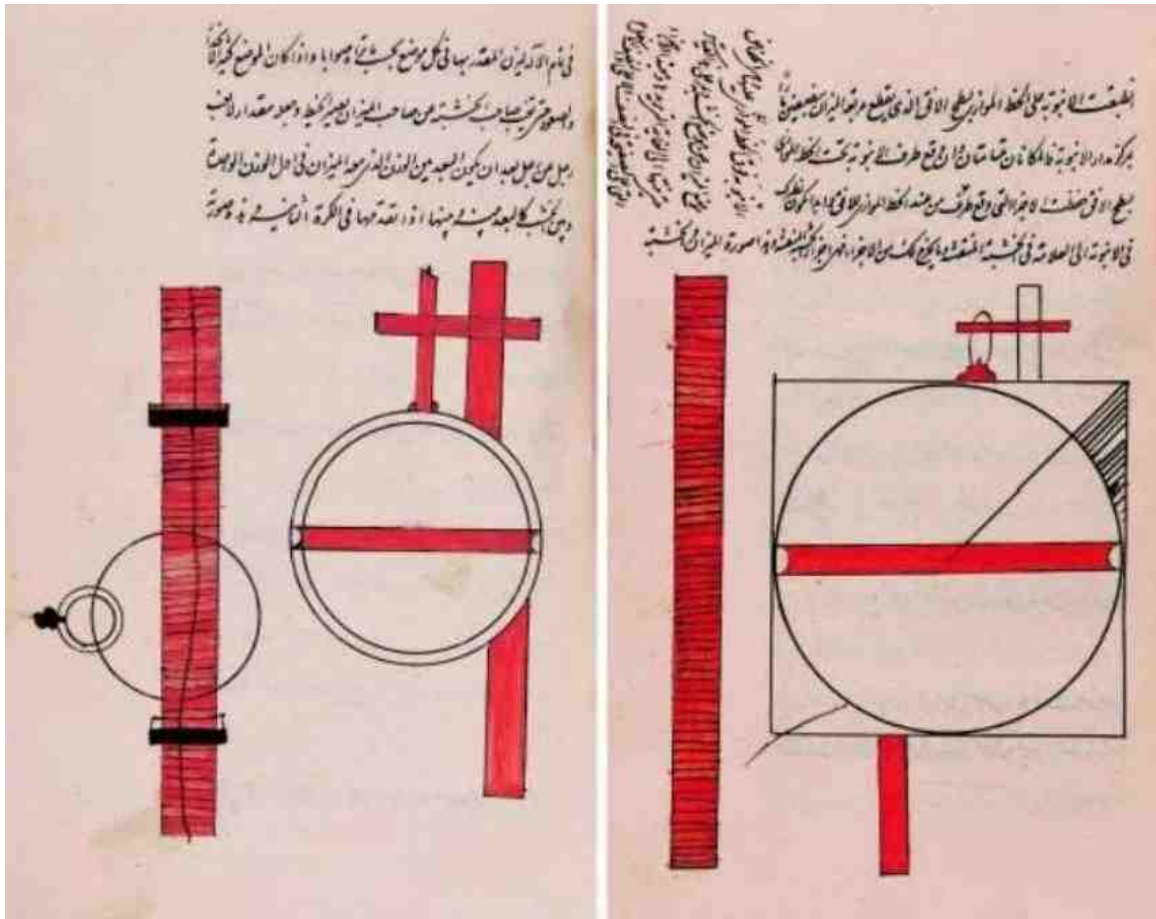


Figure 1: Two diagrams from the original manuscript of Al-Karajī's *Inbāt al-miyāh al-khafiya*, an influential work on hydraulics and water supply. Paper, 49 folios, in Arabic, nasta'liq script, black ink and over lining in red, 14 large diagrams in black and red. Rare Book and Manuscript Library, University of Pennsylvania, MS LJS 399, folios 32r, 35r.

2. The Initiative and the Collection

Established in 2007, the Lawrence J. Schoenberg & Barbara Brizdle Manuscript Initiative represents both financial and material gifts. It is the brainchild of Larry Schoenberg, a private collector of medieval and Renaissance manuscripts. The initiative is challenge-driven, with the Schoenbergs offering matching funds for the acquisition of manuscripts, with preference given to those produced before 1601. Both Larry and Barbara Schoenberg serve on Penn Libraries Board of Overseers, and are the patrons behind the Schoenberg Center for Electronic Text and Image (SCETI), and co-founders of the annual Lawrence J. Schoenberg Symposium on Manuscript Studies in the Digital Age.

The Schoenberg Collection includes three separate online sites:

- A private library of manuscripts focusing on the late medieval and early Renaissance periods. This site includes full bibliographic information for over 400 manuscripts and online facsimiles for more than 30.
- An online catalogue of the Schoenberg manuscript collection.
- A searchable database that includes catalogue descriptions of almost 100,000 early manuscripts written prior to 1600. The descriptions are derived primarily from auction and dealer records.

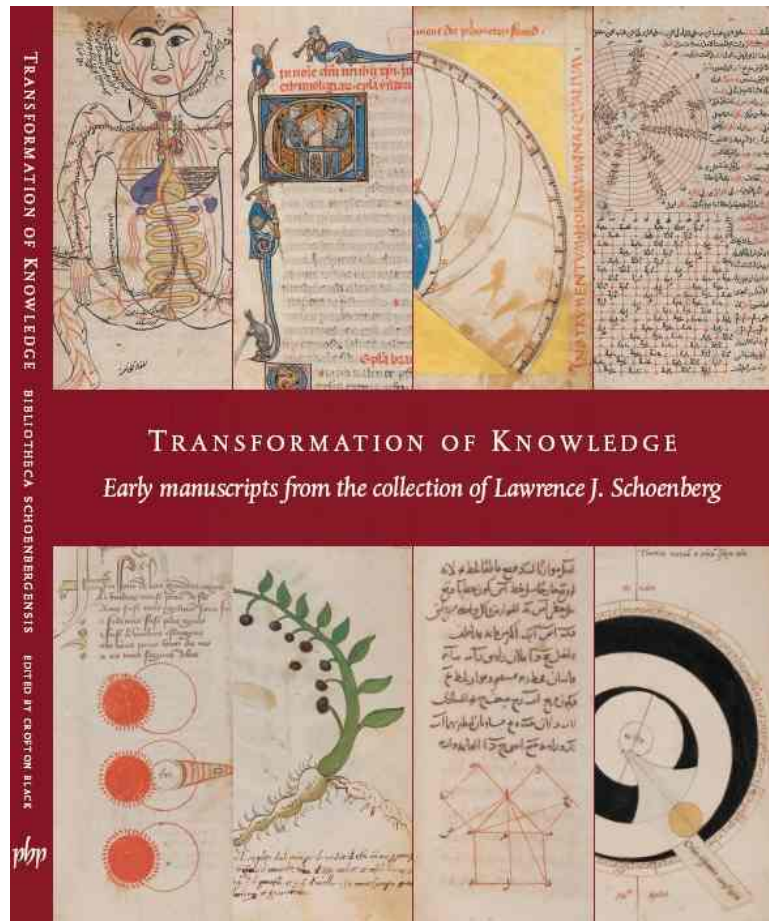


Figure 2: Front cover of the catalogue *Transformation of Knowledge: Early Manuscripts from the Collection of Lawrence J. Schoenberg*. Edited by Crofton Black, published by Paul Holberton Publishing, 2007.

Schoenberg's extraordinary collection of manuscripts is a direct and evocative testament to the range of human knowledge – mathematical, medical, astronomical, technological – as it evolved in the medieval and early modern era. This remarkable collection of manuscripts in Eastern and Western languages reflects a fascinating collection of science, medicine and technology. These hand-written volumes reveal the complexity and sophistication of pre-modern knowledge about the physical world in the Christian, Jewish, and Muslim traditions. The interdependence of these traditions, and their mutual reliance on the legacy of antiquity, are characteristic of the collection. Manuscripts, properly speaking, are not rare; they are unique. Each one provides a snapshot of one or more scholars, some well known, others unknown or anonymous, grappling with the intellectual problems of their time.

3. The Catalogue

Schoenberg's collection is described in a comprehensive catalogue edited by Crofton Black: *Transformation of Knowledge: Early Manuscripts from the Collection of Lawrence J. Schoenberg* (2007). The purpose behind this catalogue is not only to give their particulars but also to sketch their role in the history of ideas. The material gathered here spans over four thousand year of history, from the practice of arithmetic in Babylon in the third millennium BCE to a report on submarine detection experiments in 1919. The catalogue *Transformation of Knowledge* reflects the richness of Schoenberg's collection of manuscripts in a richly illustrated volume edited by Crofton Black with a preface by Lawrence J. Schoenberg and an introduction by Christopher de Hamel.

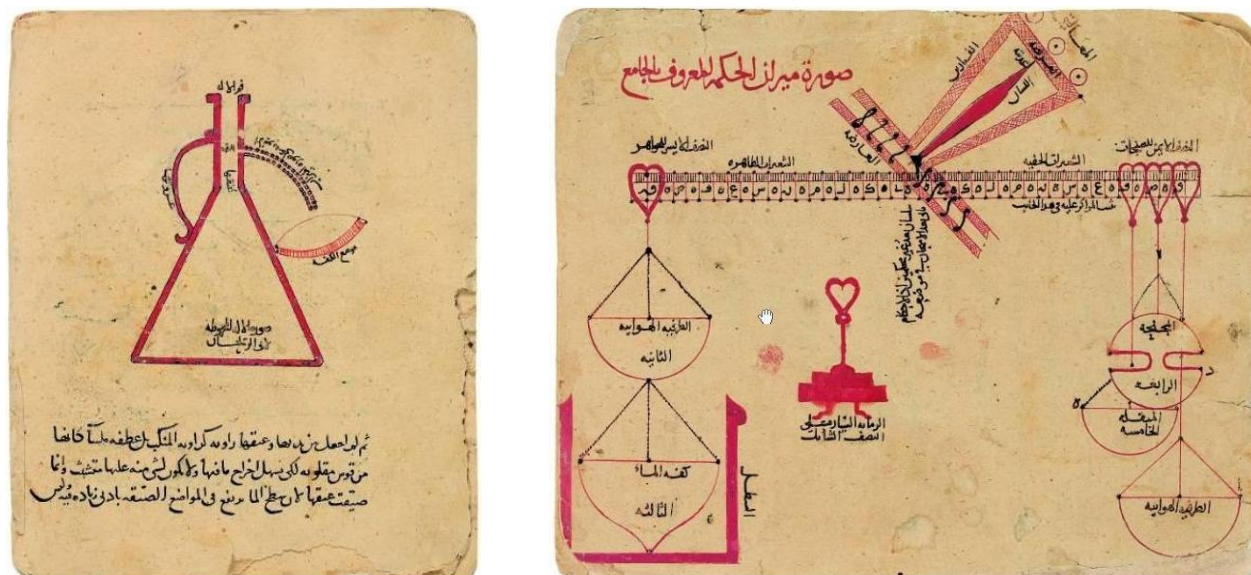


Figure 3a-b: Two pages from the manuscript of *Kitab mizan al-hikma* by ?Abd al-Rahman al- Khazini (fl. 1121) on balances and weighing instruments, bought from Sam Fogg (London) in 2000. *Mizan Al-Hikma*, ca 1270 CE, Arabic, paper, 98 leaves, with illustrations. Rare Book and Manuscript Library, University of Pennsylvania, MS. LJS 386, pp. 98, 192.

The catalogue traces the development of scientific knowledge, broadly understood, through manuscripts concerning both theory and practice – a significant number were made for teaching purposes. Beginning with *Responses to Aristotle*, the pervasive and enduring influence of Aristotelian thought throughout the Middle Ages and Renaissance is traced through manuscripts containing translations and commentaries in Latin, Arabic, Greek, Hebrew and vernacular European languages. Music, arithmetic and numerology (including games and codes), geometry, astronomy and astrology, medicine (human and veterinary), botany, chemistry and alchemy are subjects represented through manuscripts produced in Europe and the Middle East. A 1710 copy of an early work on calculus by Isaac Newton marks the beginning of a new chapter in the history of mathematics. Revealing the complexity and sophistication of medieval and Renaissance scientific thought, the catalogue indicates the roots of intercultural transmission and the lines of inquiry which ultimately led to the discoveries of Galileo, Newton, Leibniz and others.

4. Exhibition at the Getty Center in Los Angeles

The medieval and early modern manuscripts drawn from the collection of Lawrence J. Schoenberg were displayed in a recent exhibition: *Migrations of the Mind: Manuscripts from the Lawrence J. Schoenberg Collection*; Getty Center, Los Angeles, November 17, 2009–April 18, 2010. This exhibition illustrates the progression of scientific knowledge and spiritual insight through the Middle Ages and Renaissance that laid the foundation for modern secular thought. The modern division between science and religion was not shared in the medieval and early modern period. Rather, this distinction was blurred, and in some intellectual communities scientific study and its artistic expression were viewed as a form of spirituality. The manuscripts in this exhibition illustrate the transmission of knowledge as a visual process and include subjects as diverse as philosophy, astronomy, geometry, music, architecture, engineering, technology, and alchemy. An historical vision of divine creator and human creativity was demonstrated in the production of some of these manuscripts.

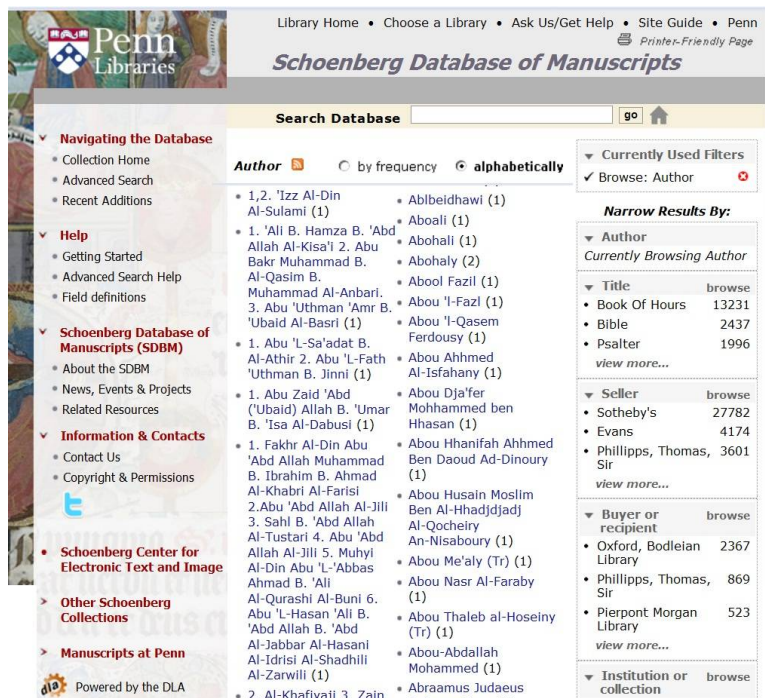


Figure 4: Screenshot of the search engine of some Islamic manuscripts in Schoenberg Database of Manuscripts. (Source).

Highlights from this extraordinary collection of illustrated manuscripts on the history of science and ideas, exhibited together publicly for the first time, demonstrate the circulation of knowledge around the world and across cultures during the medieval and early modern periods. Medieval Muslim and Christian medicine, Chinese acupuncture, secret experiments in alchemical laboratories, codebooks for keeping secrets secret, and French and Persian visions of the cosmos that blend science with spirituality were among the treasures on display. These manuscripts were produced for caliphs, popes, merchants, and scientists. Copied and illustrated by hand, their contents, their ideas and visions illustrate the human urge for knowledge and creative invention.

5. Selected Islamic manuscripts of science and medicine in Schoenberg's collection

The electronic catalogue of Schoenberg Collection at the website of the [Schoenberg Center for Electronic Text and Image](#) provides detailed descriptions of the manuscripts. We extracted from this rich catalogue the records pertaining to several Islamic manuscripts dealing with mechanics, engineering, medicine and alphabets and encoded letters.

5.1. Manuscript LJS 049

Title and date: *Tashrih Mansuri*, a medical work in Persian known in Arabic as *Rawdat al-adhan fi ma'rifat tashrih badan al-insan* (A Treatise on the Anatomy of the Human Body); Persia, 813 H (1411 CE).

Physical Description: 32 folios, 20 lines, written in a clear cursive *naskhi* script, significant words picked out in red, with five full-page anatomical diagrams, rather stained, a few holes, some mould remaining, edges frayed and repaired on Oriental paper, many notations, 6v has a small diagram, 7 has a geometric shape, 7v a diagram, 11 diagram of bones, 17v nerves, 21v veins, 23v arteries, 32 complex organs, later red morocco binding, probably an autograph copy, 245 x 174 mm.

The author of this work, Mansur ibn Muhammad ibn Ahmad ibn Yusuf Faqih Ilyas (died after 1422), was a

Persian anatomist and physician whose works were written between 1396 and 1423. This manuscript is probably an autograph copy of the author's most famous medical treatise. The *Tashrih Mansuri* (Anatomy of Mansur) is one of the most famous treatises on the human body. Written in 1396 and dedicated to Pir Muhammad Bahadur Khan, it quickly became very popular and influential.

The text consists of five chapters, a dedication, an introduction and a conclusion. The chapters discuss bones, nerves, veins, arteries/muscles, and complex organs. The chapter on bones gives their total number as 248. The nerves are described as hollow and as vehicles of the spirit and were attached to the brain. In the chapter on the veins, Mansur follows a traditional, but wrong, view previously expressed by Galen and Avicenna. He overlooks the century earlier revolutionary discovery by Ibn an-Nafis of the pulmonary circulation of the blood. The text is not completely original but it is very well organized and was used for generations of medical students. "The most remarkable feature of this treatise is the group of five colored schematic drawings illustrating respectively the bones, nerves, veins, arteries, and a woman's body with a womb containing a ripe foetus", Sarton, *Introduction to the History of Science*, 1948, p. 1729-30. The colophon on the penultimate folio of the present copy states that it was completed by the author himself in the month of Dhu 'l-hijja in the year 813 H (1411 CE), making it an extraordinary survival and one of the earliest codices of this seminal medical work. Remarkably, this codex has a different title (written in the same ink and handwriting as the rest of the text) and a slightly different name of the author including his *nisba* (indication of origin) - al Kashmiri al-Balkhi. None of the catalogues of the European, American or Asian collections suggests that they possess a copy written by the hand of the author.

Illustrations:

F. 12: bones; f. 17v: nerves, there are no visible muscles in this drawing, words are used to indicate their position; f. 21v: veins; f. 23v: arteries; the alimentary system showing a stomach and a liver can be seen in the drawing; f. 31: arterial system of a pregnant woman, a woman's body with a womb containing a ripe fetus.

There is an indication that there was another picture prior to this one. Although Sarton (*Introduction to the History of Science, Volume III*, p.1729) and Ernest Sudhoff (*Drei weitere anatomische Fnfbilderserien aus Abendland und Morgenland*, AGM 3, pp. 165-87, 347-8) indicate that the five illustrations shown here are the standard for this text, there are some copies with a sixth illustration showing the muscles. There are at least 10 illustrated copies of the text.

Bibliography: C. E. Storey, *Persian literature*; Sarton, George, *Introduction to the History of Science*, Volume III, p. 1729; *Lithographic edition of Tashrih-i Mansuri*, Delhi, India 1847/48; Fonahn, Adolf M., *Zur Quellenkunde der persischen Medizin*, Leipzig: Zentral-Antiquariat der Deutschen Demokratischen Republik, 1968; Sudhoff, Karl, *Ein Beitrag zur Geschichte der Anatomie im Mittelalter*, Hildesheim: G. Olms, 1964; Choulant, Ludwig, *History and Bibliography of anatomic illustration*, pp. 49, 58, 68; other mss. Schab, cat 9, no.179; Sotheby's Islamic sale, London, 18 October 1995, lot 51; Maggs Bros., cat. 542 (*The Art of Writing*), 1930, no. 213; recorded other mss. are in the India Office, London, Persian Ms. 2296 dated 5 December 1672; Bibliothèque Nationale, Paris, Persian Ms. 1555 (Schefer, p. 239); British Museum, London, Add. Ms. 23556, dated 1684; Bodleian Library, Oxford, Ms. 1576 (Fraser 201) dated 13 February 1722; Berlin, a copy sold at Sotheby's, 11 July 1966, lot 151, Sotheby's, 11 December 1968, lot 152.

5.2. Manuscript LJS 051

Title and date: [A Book of Alphabets and Encoded Letters], Syria?, XVth century.

Physical Description: 106 folios, collation:I2, II10, III-IV8, V10, VI4, VII6, VIII-XII10, XIII8, with catchwords

in the lower left corner of each verso, 1 column, 13 lines, written in black *naskhi* and a variety of other scripts, some with the Arabic equivalent written above in red, occasional notes in the margins, half-leather binding, stamped, over plan varnished wood, with paper endsets, some staining and damage, lacking at beginning and end, 178 x 133 (119 x 82) mm.

A remarkable record of encrypted correspondence together with Arabic translations. This volume records communications written between the compiler and various correspondents. The original communications are in approximately one hundred and fifty invented and different 'alphabets', some of the letters of which have had the Arabic equivalent written above in red, possibly at a later date. They are decoded and transcribed also in Arabic. Islamic science is an important branch of Arabic medieval knowledge. It was an integral part of Islamic agriculture, chemistry, medicine and mathematics. Islamic culture developed numerous cryptograms for use by close social groups including scholars and magicians as well as tradesmen. They developed arcane scripts for bookkeeping and recording numbers. There are several other Islamic works on cryptograms including Ibn Wahshiyya's *Kitāb Sharh al-mustaham fi Ma'rifat Rumuz al-Aqlam* and the book called the *Book by Ishrasim*.

There is no colophon and neither the author nor the copyist is named in the text. The author's correspondents include Sharaf al-dīn Musa ibn Ijlī al-Barīdī, Shams al-Dīn al-Ridhā and, probably the most frequent, al-Shaykh Shihab al-Dīn Ahmad al-Mutarjim who is also called al-Makhdumi al-Alafi. This is a slightly corrupted form of the name Shibab ad-Dīn al-Djundi al-Alafi who is also the author's major authority for the codes. Other authorities mentioned include Burhan al-Dīn al-Qudsi al-Hanafi and Taqi al-Dīn Muhammad ibn Ja'far al-Husayni. The text mentions the towns of Aleppo and Damascus and one of the passages recounts something that occurred in 'the 730s' H (= 1330s CE). This date would be consonant with the script and format of the book. The material is similar to the manner of explanation and arranging of Aydamir Djildaki, a well-known Arab alchemist who died in Cairo in 1342.

One of the alphabets employed, the 'tree-like' alphabet (al-qalam al-mushajjar) is identical to one of the same name given in the *Kitāb Shawq al-mustaham fi ma'rifat rumuz al-aqlam* (Book of the frenzied devotee's desire to learn about the riddles of ancient scripts) written in about 241 H (855 CE), where its invention is ascribed to Abū Bakr Ahmad ibn 'Alī ibn Wahshiyyah; edition and English translation by J. Hammer-Purgstall, *Ancient Alphabets and Hieroglyphic Characters Explained; with an Account of the Egyptian Priests, the Classes, Initiation and Sacrifices* (London 1806), p. 38. Features of some of the other alphabets employed in this manuscript are also to be found in the treatise attributed to Ibn Wahshiyyah but many of the alphabets are quite different.

While some of the characters in the alphabet used bear a structural or aesthetic resemblance to characters of the Arabic or Hebrew alphabets, the primary influence on their forms seems to be from the old square inscriptional forms of Aramaic. Some of the characters are composed of lines and combinations of lines ending in small circles, a resemblance to the *Kalmosin* or Angelic script used among Jews for cabalistic, alchemical and astrological symbolism and occasionally for ciphers. It is thought that these may have evolved from the copying onto papyrus or vellum of the hieroglyphic script of the Akkadians.

In the medieval Christian world cipher-alphabets were not frequently used. The preferred method was the systematic substitution of each Latin or Coptic letter by another. The nature of Arabic script, which involves many compulsory ligatures between neighboring letters and the use of variant forms at word-endings, was not conducive to the application of this kind of substitution cipher, encouraging the use of these arcane alphabets as an alternative method.

5.3. Manuscript LJS 355

Title and date: *Kitab al-qanun fi at-tibb*, edited by Muhammad Fali al-Katib, date in colophon, Ramadan 608 H/ 1212 CE, but probably 15th century.

Physical Description: Folio, 182 folios, collation: 1-1810, 192, contemporary Eastern Arabic foliation on lower center margin of each recto reaches [180] instead of [182], catchwords on every verso, single column of 51 lines, single-fillet border in black ink, written in black ink in a clear *naskhi* script, significant words in red, some restoration, in leather binding with tooled shamstyryas, the last three books with 2 missing folios, 320 x 215 (257 x 164) mm.

Abū Ali al-Husayn ibn Abdullah ibn Sinā (Latin: Avicenna), (Kharmaiten near Bukhara 980-1037 CE) was an outstanding and most famous Islamic scientist, philosopher and physician. The present text *al-Qānūn fi-l-tibbor Liber Canonis (Canon of Medicine)* is perhaps one of the greatest medical books in history. "It is an immense encyclopedia of medicine (of about a million words), a codification of the whole of ancient and Muslim knowledge" (Sarton, vol. I, p.710). The work is based on Galen and Hippocrates who had already been translated from Greek to Arabic. Although he borrowed from these authors, Ibn Sinā compiled the text over a long period of time and in different places. He introduced the results of his own long medical practice and scientific research, producing a work which was a standard in Muslim and Jewish culture and was immediately accepted as authoritative in Europe when it was translated into Latin. It was the first classified description of the human body, its diseases and their treatment. The *Qānūn* is a work of major importance in the histories of both Eastern and Western medical traditions. It was highly prized throughout the Islamic world where it was a standard text for seven centuries. In addition, it played in its Latin translation, a significant part in the development of pre-modern European medicine.

The whole work consists of five books, each book is divided into 'parts' (*fan*), 'instructions' (*ta'lim*), 'sums or classes' (*gumla*), 'divisions' (*fasl*) or 'articles' (*maqala*). The first book comprises the general knowledge of medicine and the second deals with simple drugs. This manuscript contains the last three books. The third describes disease of the head and then pathology, the fourth describes diseases of the body and cosmetics and the last book has information about compound drugs, ointments and electuaries.

A text of this importance was, of course, copied many times. Yet there is still no critical edition nor a complete textual history. Every manuscript of the *Qānūn* has therefore a possible formative role in the history of the text when it is finally written.

This manuscript LJS 355 is clearly laid out in a good but non-professional hand. This would suggest that it was for the use of a practitioner. It differs somewhat from the common version of the text. The colophon states that the book was edited by Mohammed ben Abi Shuja' ben Mohammed ben 'Ali al-Katib in the month of Ramadan 608 H (1212 CE). The paper stock suggests a date in the 15th century.

Bibliography: *Encyclopedia of Islam*, 7 vols., 2nd ed., Leiden: 1960, *Encyclopedia of the History of Arabic Science*, vol. 3, pp. 970-977, chapter by Danielle Jacqart, London: Routledge, 1996.

5.4. Manuscript LJS 386

Title and date: *Kitab Mizan al-Hikma* (Book of the Balance of Wisdom), ca 1270 CE.

Physical Description: 98 folios, some still in quires, 15 lines of neat *naskhi* script in black ink, section headings in larger *riqa* script in black ink, the first few opening lines are missing as well as the conclusion and some intervening sections, a few catchwords added later, as have occasional miniscule letters written under some of the undotted (*muhmal*) letters, paginated in a recent European hand, all of the major illustrations are intact and include 26 diagrams and 18 tables in red and black ink, some staining, many

pages eaten away around the margin without loss of text, unbound in a dark green folder and box, text area 140 x 110 mm., 195 x 150 mm.

ʿAbd al-Raḥmān al-Khāzinī flourished in Marw (Merv in Turkmenistan), in the first half of the 12th century (around 1115-31). The main domains of his scientific activity are astronomy, mechanics, and scientific instruments. The most important of Al-Khāzinī's works is *Kitāb mīzān al-ʿikma* (Book of the Balance of Wisdom), a treatise completed in 515 H (1121/1122) on the physical principles that underlie the hydrostatic balance as well as the construction and use of the instrument.

The main application of Al-Khāzinī's *mīzān al-ʿikma* (balance of wisdom) or *al-mīzān al-jāmiʿ* (universal balance) was to discriminate accurately between pure and adulterated metals as well as between real gems and fakes. Al-Khāzinī's treatise is a long work, divided into eight books and eighty chapters, and its quotations bear witness to the classical sources, Greek and Arabic, on theoretical and applied mechanics until Al-Khāzinī's time (Pseudo Aristotle, Pseudo Euclid, Archimedes, Menelaus, Al-Isfizārī, Thābit ibn Qurra, Al-Rāzī, Al-Bīrūnī, Ibn al-Haytham, Al-Qūhī, and Al-Khayyām).

The book covers a wide range of topics related to statics, hydrostatics and practical mechanics; it discusses the definition of heavy and light, the centre of gravity, the stable and unstable equilibrium, as well as the theory of the definition of specific gravities and even the application of the balance for levelling and for measuring time. The second part of the book describes the construction and use of the so-called "balance of wisdom," a sophisticated instrument capable of measuring absolute and specific weights of solids and liquids and of calculating exchange rates of currencies. This balance was used for ordinary weighing, as well as for all purposes connected with the measuring of specific gravities, distinguishing of genuine and false metals, examining the composition of alloys, etc. In all these processes, the plates are moved until equilibrium is obtained and the desired magnitudes in many cases can at once be read on the divisions of the beam.

Al-Khāzinī's hydrostatic balance was superior in its accuracy to all those constructed by his predecessors. According to Al-Khāzinī's accurate descriptions, it was aimed at calculating tables of the specific gravities of many substances, both metallic and non metallic, attaining, in some cases, results which are correct to within one percent.

Bibliography: Abattouy, Mohammed 2007: "Abd al-Raḥmān al-Khāzinī." In: *The Biographical Encyclopedia of Astronomers*. Edited by Thomas Hockey. Berlin/Heidelberg/New York: Springer Verlag, pp. 629-630; Al-Khāzinī, 1359 H [1940]: *Kitāb Mīzān al-ʿikma*. ʿaydarabad: Dāʿirat al-Maʿārif al-ʿUthmāniyya; Bauerreiß, Heinrich 1914: *Zur Geschichte des spezifischen Gewichtes im Altertum und Mittelalter*. Erlangen: Jung & Söhne; Hall, Robert E. 1973: "Al-Khāzinī." *Dictionary of Scientific Biography*, edited by Charles C. Gillispie. New York: Charles Scribner's Sons, vol. 7, pp. 335-351; Khanikoff, Nicholas 1860: "Analysis and Extracts of *Kitāb Mizan al-Hikma*, an Arabic Work on the Water-balance, written by 'al-Khāzinī in the Twelfth century." *Journal of the American Oriental Society* vol. 6: pp. 1-128; Lorch, Richard 1980: "Al-Khāzinī's Sphere That Rotates by Itself." *Journal for the History of Arabic Science* vol. 4: pp. 287-329; Pingree, David 1999: "A Preliminary Assessment of the Problems of Editing the *Zīj al-Sanjārī* of al-Khāzinī." *Editing Islamic Manuscripts on Science*, edited by Yusuf Ibish. London: Al-Furqān Islamic Heritage Foundation, pp. 105-113; Sayili, A. 1956: "Al-Khāzinī's Treatise on Astronomical Instruments." *Ankara Üniversitesi Dil ve Tarih-Cografya Fakültesi Dergisi* vol. 14: pp. 15-19; Wiedemann, Eilhard 1913-16: "Al-Mīzān." In: *The Encyclopedia of Islam, First Edition*. Leiden: Brill, vol. 5, pp. 530-539.

5.5. Manuscript LJS 399

Title and date: *Inbāt al-miyāh al-khafiyah* (the search for hidden waters). Iraq or Persia, 20 February 1674 (14 Dhu'l Qa'da 1084 H).

Physical Description: 49 folios, 15 lines, rubrication and overlining in red, catchwords, 14 large diagrams in black and red, written in a *nasta'liq* script in black ink, brown morocco binding, blind-tooled, damaged and rebacked, 190 x 125 mm.

Abū Bakr Muhammad ibn al-Hasan al-Karaji (953-c.1029 CE) was a famous mathematician who left Baghdad in his later years to live in the mountains. He then wrote this treatise on the tapping of subterranean waters around 1011 CE. The introduction to the manuscript indicates that this work was written in Iraq, as were the author's other algebraic works. *Inbāt al-miyāh al-khafiyyah* (the search for hidden waters) is "an excellent manual on hydraulic water supplies; it contains some autobiographical notes, as well as a discussion of a series of conceptions relative to the geography of the globe; [it] describes a number of surveying instruments, the geometrical bases of which he demonstrates, and ends with very concrete details on the construction and servicing of 'qanats', subterranean tunnels for providing water in arid places. He likewise discusses the basis of the Shar'ia, the legality of the construction of wells and hydraulic conduits and in what circumstances these might be prejudicial to the people" (*Encyclopedia of Islam*, IV, pp. 599-600).

The chapters listed below amply demonstrate that al-Karaji takes the reader through every stage of building a "qanat" from determining where to drill the test well to the upkeep of the completed 'qanat':

- On the earth (al-'ardh)
- On subterranean waters (*al-miyah al-khafikah*)
- On plants that indicate the presence of water
- On barren mountains
- Types of water and their tastes
- On the various qualities of different types of water
- How to clean contaminated water
- On the seasons
- On soil
- On the sayings of the elders
- On caves and dried wells and how to determine if water can be found
- On earthquakes and the appearance and movement of springs
- On bringing water to the surface and the use of pipes
- On what the Elders said about springs in barren land
- Things that should not be done in 'qanats' and wells
- A further list of things not to be done in 'qanats' and wells
- On obstructions encountered when drilling for water
- On steam emanating from wells
- The force of water as an obstruction
- On the use of a 'tower' to divert the water
- On putty to attach to the 'tower'
- On changing the position of the 'tower'
- On water measures
- On old water measures
- Measurement of mountains
- The construction of 'qanats'
- On the straightness of drills under the earth in barren areas and springs
- Drilling with drills, which are not straight
- On the preservation of 'qanats' from becoming ruined
- How to deal with blockages
- Maintenance of 'qanats'.

Bibliography:

Mohammed Abattouy, [Muhammad Al-Karaji: A Mathematician Engineer from the Early 11th Century](#); Roshdi Rashed, "L'induction mathématique: Al-Karaji et As-Samaw'al", *Arch. Hist. Exact Sci.* 1 (1972), pp. 1-21; ; R Rashed, Al-Karajī, in *Dictionary of Scientific Biography* (New York 1970-1990), online at [Complete Dictionary of Scientific Biography](#), 2008; K. H. Parshall, "The art of algebra from al-Khwarizmi to Viète: A study in the natural selection of ideas," *Hist. of Sci.* 26 (72, 2) (1988), pp. 129-164; J. Sesiano, "Le traitement des équations indéterminées dans le *Badi fi al-Hisab* d'Abu Bakr Al-Karaji," *Arch. History Exact Sci.* 17 (4) (1977), 297-379; Nasr, *Islamic Science*, pp. 52 and 214; Sarton, pp. 718-9; Hill, *Islamic Science and Engineering*, p. 187.

6. Appendix

Contents of the catalogue *Transformation of Knowledge: Early Manuscripts from the Collection of Lawrence J. Schoenberg* (2007).

Preface
 Introduction
 Overview
 I. Responses to Aristotle
 II. Music
 III. Mathematics
 IV. Astronomy, Astrology and the Calendar
 V. Medicine
 VI. Alchemy and Chemistry
 VII. Technology
 VIII. Agriculture and Animal Husbandry
 IX. Organization of Knowledge
 X. Writs and Charters
 Concordance
 Bibliography
 Index

7. Resources and further reading

– [Schoenberg Collection home page](#)
 – [Bibliotheca Schoenbergensis Exhibition](#)
 – [The Schoenberg Center for Electronic Text and Image](#)
 – [Lawrence J. Schoenberg Collection– Scheoneberg Center for Electronic Text & Image](#)
 – *Transformation of Knowledge: Early Manuscripts from the Schoenberg Collection*. Edited by Crofton Black, published by Paul Holberton publishing, first edition February 2007. Paperback: 208 pp.; 200 colour illustrations. ISBN-10: 1903470501 - ISBN-13: 978-1903470503.
 – [Getty Research Institute Reveals Scientific Knowledge and Spiritual Insight from The Medieval And Early Modern Period: Migrations of the Mind: Manuscripts from the Lawrence J. Schoenberg Collection](#); Getty Center, Los Angeles, November 17, 2009–April 18, 2010.
 See also ([Getty Research Institute Reveals Scientific Knowledge And Spiritual Insight From The Medieval And Early Modern Period](#) (PDF) ; News From The Getty (October 8, 2009).